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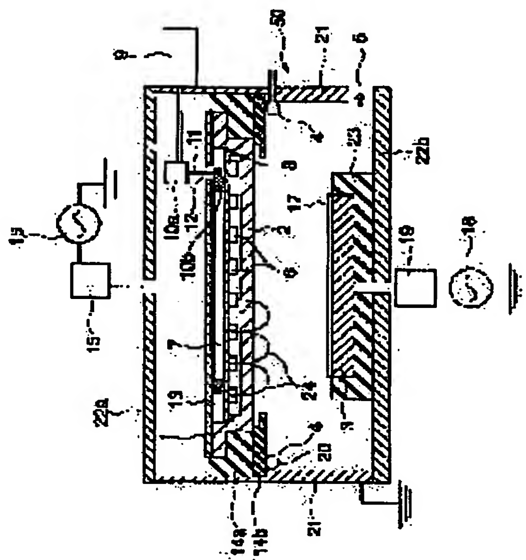
(71)Applicant : ANELVA CORP
(72)Inventor : SNIL WIKURAMANAYAKA
WATANABE EISAKU
NAGAHAMA HANAKO
SATO MAKOTO
MIZUNO SHIGERU

(54) PLASMA TREATMENT DEVICE FOR SPUTTERING FILM DEPOSITION

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a capacity-coupling type plasma treatment device for sputtering film deposition in which ion flux is uniformly deposited on a surface of a substrate at high concentration, but not re-deposited on a target.
SOLUTION: The plasma treatment device comprises an upper electrode 1 having a capacity-coupling type mechanism, a target member 2 fitted to the upper electrode and formed of a non-magnetic substance, a plurality of magnets 6 which are disposed on an upper surface of the target member having alternately changing polarity at equal intervals between the two magnets, a lower electrode 3 disposed parallel to the upper electrode, a wafer 17 mounted on the lower electrode, and a high frequency power source 16 which is operated at the frequency in a range of 10-300 MHz, and connected to the upper electrode via a matching circuit 15.



【外国語明細書】

1. Title of the Invention:

A plasma processing system for sputter deposition applications

2. Claim:

[Claim 1]

A plasma processing system for sputter deposition applications characterized by comprising:

a reactor having gas introducing inlets and a vacuuming outlet,

an upper electrode with a capacitively coupled mechanism arranged in said reactor,

a target member of non-magnetic material attached to said upper electrode,

a plurality of magnets arranged over an upper surface of said target member and within a cavity between said upper electrode and said target member, which have a equal distance between two of them and alternate polarity,

a lower electrode placed parallel to said upper electrode in said reactor, wherein a wafer to be processed is loaded on said lower electrode, and

an rf power source operating at a frequency in a range of 10 MHz to 300 MHz connected to said upper electrode via a matching section.

[Claim 2]

A plasma processing system for sputter deposition applications as claimed in claim 1, characterized in that said plurality magnets are rotated by a rotating mechanism around a central axis of said upper electrode.

[Claim 3]

A plasma processing system for sputter deposition applications as claimed in claim 2, characterized in that said rotating mechanism is comprised of a motor, a first gear device connected to the motor, a second gear device arranged to a sheet provided with said magnets, and a rod made of an insulating material connecting the first and second gear devices.

[Claim 4]

A plasma processing system for sputter deposition applications as claimed in any one of claims 1 - 3, characterized in that said upper electrode is connected to a DC voltage supply via an rf cut-off filter.

[Claim 5]

A plasma processing system for sputter deposition applications as claimed in any one of claims 1 - 4, characterized in that said upper electrode is connected to a secondary rf power supply via the matching section.

[Claim 6]

A plasma processing system for sputter deposition applications as claimed in any one of claims 1 - 5, characterised in that height of said magnets arranged over the upper surface of said target member varies in radial direction.

[Claim 7]

A plasma processing system for sputter deposition applications as claimed in any one of claims 1 - 6, characterised in that strength of said magnets arranged over the upper surface of said target member varies in radial direction.

3. Detailed Description of Invention:

[0001]

[Field of Industrial Application]

The present invention relates to a plasma processing system for sputter deposition applications, and more particularly, to a plasma assisted sputtering system having an improved plasma source capable of independently controlling plasma ion density and ion energy at an rf (HF or VHF) electrodes useful for a sputtering process of metal or dielectric materials during the fabrication of integrated circuits in the semiconductor industry.

[0002]

[Prior Art]

Large-area and high-density plasma sources with higher radial uniformity are of great demand to process large area substrates without charge-induced damages to the devices fabricated on the substrate surface. Specially, development of new plasma sources for the sputtering process of metal and dielectric materials with enhanced uniformity of the deposited film is of important. Difficulties in obtaining the above-mentioned properties with conventional plasma sources are explained using two conventional configurations as shown in Figs. 6 - 9, which are usually applied in 200 mm wafer or flat panel plasma processing systems.

[0003]

Fig. 6 shows a simplified conventional magnetron-type plasma source that uses for sputter deposition applications in semiconductor industry. A reactor 101 is comprised of an upper electrode 102 made of a non-magnetic metal, a cylindrical side wall 103 and a lower electrode 104. The upper electrode 102 forms a top plate of the reactor 101 and the lower electrode 104 is arranged on a bottom plate 105 of the reactor 101. The upper electrode 102 and the lower electrode 104 are parallel to each other across at least over a portion of the reactor 101. The side wall 103 and the bottom plate 105 are made of a metal, for example stainless steel. The side wall 103 and the bottom plate 105 are grounded. The n

pper part of the side wall 103 is extended upward to make a room at the outside of the reactor. The side wall 103 has a dielectric ring 106. A target plate 107 made of a material needed to be sputtered is fixed to the lower surface of the upper electrode 102. Usually, the target plate 107 has slightly smaller dimensions in comparison with the upper electrode 102. The composite structure of the upper electrode 102 and the target plate 107 are placed on the dielectric ring 106 in order to electrically isolate from the rest of the reactor 101. On the upper surface of the upper electrode 102, two magnets 108a and 108b of circular and ring shapes are concentrically placed as shown in Figs. 6 and 7. The two magnets 108a and 108b are fixed to the upper electrode 102 and a plate 121 used as a magnetic route is placed on the tow magnets 108a and 108b. The central magnet 108a is of a cylindrical shape without any cavity as shown in Fig. 7. The outer magnet 108b is of a ring shape. The height and widths of each of the magnets 108a and 108b are not critical and selected according to the other dimensions of the reactor 101. The magnets 108a and 108b are placed on the upper electrode 102 so as to have opposite polarities facing the inside of the reactor 101. This arrangement of the magnets 108a and 108b generates curved magnetic fields 109 between these two magnets.

[0004]

The upper electrode 102 is connected to an rf electric power source 110 operating at a frequency in the range of 0.1 MHz to 300 MHz through a matching circuit 111. The frequency of the rf electric power source 110 is usually 13.56 MHz. When an rf electric power is applied to the upper electrode 102, plasma is generated by the capacitively-coupled mechanism. Once the plasma is made, electrons in the plasma are confined within the curved magnetic fields causing an increase of plasma density in that region.

[0005]

A substrate 112 is placed on the lower electrode 104 which is electrically isolated from the bottom plate 105 through an insulating material 113. The lower electrode 104 may or may not be given an rf electric power from an rf power source. If an rf electric power is supplied to the lower electrode 104 by an rf electric power source 114 through a matching circuit 115, as shown in Fig. 6, the frequency of the rf electric power source 114 usually lies in the region of 0.1 MHz to 30 MHz. When an rf current is applied to the lower electrode 104, it gets negatively biased causing an ion bombardment onto the surface of the substrate 112. Though the ion bombardment causes an etching process on films deposited on the substrate 112, the self bias voltage of the lower electrode 104 is controlled so that the film deposition rate exceeds the film etching rate on the substrate 112.

[0006]

Another conventional magnetron type sputtering source shown in Fig. 8 is a slight modification of the above-mentioned plasma source given in Fig. 6. Here the central magnet 108a is placed in an off-axis mode in order to form an asymmetric magnetic field 109 below the upper electrode 102. A top view of this magnet arrangement is shown in Fig. 9. This magnetic configuration is rotated around a central axis (shown as a dashed line 116 in Fig. 8) of the upper electrode 102. The magnet arrangement formed by the magnets 108a and 108b shown in Figs. 8 and 9 rotates asymmetrically.

[0007]

[Problems to be solved by the Invention]

The parallel plate plasma reactor shown in Fig. 6 has several advantages such as large area plasma between the parallel electrodes, readily ignition of the plasma, and the ability of controlling plasma ion en

ergy at the lower electrode surface. With the magnet arrangement given in Fig. 6, a doughnut-shaped curved magnetic field is generated below the upper electrode 102. Once the plasma is ignited, higher-density plasma of the doughnut-shaped is formed below the upper electrode 102 due to the magnetic confinement of electrons. Since this higher-density plasma is mainly confined within the region between the magnetic poles of the magnets 108a and 108b, there is a lower plasma density in the vicinity of the magnetic poles.

[0008]

Further, the strength of the magnetic field increases toward the magnetic poles. This causes a mirror reflection of the electrons that result in lower electron density at the magnetic poles of the magnets 108a and 108b. When the electron density is low, the ion density is also gets low since ions are trapped in the plasma by electrostatic fields generated by electrons.

[0009]

Because of the two reasons explained above, the ion flux at the magnetic poles gets smaller to result in a lower sputtering rate. However, since there is a higher-density plasma in the doughnut-shape region between the respective magnetic poles of the magnets 108a and 108b, the area of the target plate 107 corresponding to the region between the two magnets gets strongly sputtered. A fraction of these sputtered atoms are reflected back due to the scattering by gas molecules and deposited again on the target plate 107. Since the sputtering rate at the places of the target plate surface corresponding to the magnetic poles is relatively smaller, deposition of the sputtered atoms at these places gets dominant. The re-deposited film, however, has a lower density and stick loosely on the target plate 107, thus it can be easily released as particles. Moreover, due to the etching of only the doughnut shaped region, the

utilization efficiency of the target greatly reduces.

[0010]

In order to avoid the re-deposition of sputtered materials on the target plate 107, as shown in Fig. 8, the magnets 108a and 108b are placed asymmetrically and rotated around the central axis 116 of the upper electrode 102. Even though there is the re-deposition of sputtered materials at the places corresponding to the magnetic poles, the re-deposited films are immediately sputtered back into the plasma due to the rotation of the magnets. Accordingly, the source of particles in the plasma can be eliminated.

[0011]

However, the plasma generated with the configuration given in Fig. 8 is radially non-uniform. This causes a non-uniform ion flux onto the surface of the substrate 112. This may cause localized charge build up on the substrate surface, specially if the substrate 112 is negatively biased by applying the rf electric power to the lower electrode 104, which eventually results in electrical breakdown of sub-micro scale elements on

the substrate 107.

[0012]

An object of the present invention is to provide a magnetically enhanced capacitively-coupled plasma processing system for sputter deposition applications with higher ion concentration, higher ion flux uniformity on the wafer or substrate surface and without the re-deposition of sputtered materials back on the target member.

[0013]

[Means to solve the Problem]

A plasma processing system for sputter deposition applications in accordance with the present invention has a reactor, an upper electrode

, a target member, a plurality of magnets, and an rf power source. The reactor has gas introducing inlets and a vacuuming outlet. The upper electrode is provided with a capacitively coupled mechanism and arranged in the reactor. The target member is made of non-magnetic material and attached to the upper electrode. The plurality of magnets is arranged over the upper surface of the target member and within a cavity between the upper electrode and the target member, which have a equal distance between two of them and alternate polarity The lower electrode is placed parallel to the upper electrode in the reactor, and a wafer (or substrate) to be processed is loaded on the lower electrode. The rf power source operates at a frequency in a range of 10 MHz to 300 MHz and is connected to the upper electrode via a matching section.

In the above plasma processing system for sputter deposition applications, preferably, the plurality of magnets is rotated by a rotating mechanism around a central axis of the upper electrode.

In the above plasma processing system for sputter deposition applications, preferably, the rotating mechanism is comprised of a motor, a first gear device connected to the motor, a second gear device arranged to a sheet provided with the magnets, and a rod made of an insulating material connecting the first and second gear devices.

In the plasma processing system for sputter deposition applications, preferably, the upper electrode is connected to a DC voltage supply via an rf cut-off filter.

In the plasma processing system for sputter deposition applications, preferably, the upper electrode is connected to a secondary rf power supply via the matching section.

In the plasma processing system for sputter deposition applications, preferably, height of the magnets arranged over the upper surface of the target member varies in radial direction.

In the plasma processing system for sputter deposition applications, preferably, strength of the magnets arranged over the upper surface of the target member varies in radial direction.

[0014]

The configuration of the above present invention maintains a magnetically enhanced capacitively-coupled plasma below the target member. The magnets are arranged to generate a cluster of point-cusp magnetic fields below the target member, therefore, there is a higher magnetic field strength at the vicinity of target member resulting in a higher plasma density. Owing to the rapid decay of magnetic field towards the lower electrode where a wafer is placed, wafer is in a magnetic field-free environment. This facilitates to apply an rf electrical power to the lower electrode in order to give a negative bias voltage to the wafer. Further, due to the rotation of magnet arrangement, re-deposition of sputtered atoms on the target is prevented and the erosion profile of the target gets almost uniform.

[0015]

[Working Example of Invention]

Hereinafter, preferred working examples will be explained according to attached drawings. Through the explanation of the working examples, the details of the present inventions will be clarified.

[0016]

The first working example of the present invention will be explained in accordance with Figs. 1 and 2. Figs. 1 and 2 show views of a plasma source used for a plasma processing system of the first working example. Fig. 1 shows a cross sectional view of the plasma processing system and Fig. 2 shows the magnet arrangement.

[0017]

In the above plasma processing system, a reactor 50 is comprised

of an upper electrode 1, a target member 2, a lower electrode 3, a cylindrical side wall 21, a top plate 22a, a bottom plate 22b, and a wafer holder 23. The target member 2 is arranged to the power surface of the upper electrode 1. A plurality of magnets 6 is arranged over the upper surface of the target member 2 and in a cavity 13 between the upper electrode 1 and the target member 2. Further, the reactor 50 has gas inlets 4 and a vacuuming outlet 5. This vacuuming outlet 5 is connected a vacuum pump (not shown).

[0018]

The upper electrode 1 is made of a metal, for example, Al, and placed on a ring 14a made of a dielectric material, for example, ceramic. The upper electrode 1 is of a circular shape. The dimensions of the upper electrode 11 are not critical and depend on the size of a substrate to be processed. The cylindrical side wall 21, the top plate 22a and the bottom plate 22b are made of a metal and electrically grounded.

[0019]

The target member 2 is made of a metal, for example Cu, that needs to be sputtered and deposited on a surface of a wafer 17. This wafer 17 is loaded on the lower electrode 3 arranged in the wafer holder 23. The target member 2 is tightly fixed to the upper electrode 1, for example, by bolts or by diffusion bonding. The shape of upper electrode 1 and the target member 2 is designed so that there is the cavity 13 between the upper electrode 1 and the target member 2. The diameter of upper electrode and the target member are not critical and selected depending on the diameter of the wafer 17. For example, if the wafer diameter is 200 mm, the target diameter may lie in the range of 200 mm to 350 mm. The thickness of the target member 2 below the magnets 6 is also not critical and usually lies around 15 mm.

[0020]

The arrangement of the magnets 6 within the cavity 13 between the upper electrode 1 and target member 2 is shown in Fig. 2. The plurality of magnets 6 is fixed to a circular sheet 7. The magnets 6 are arranged with equal distance to each other and with alternate polarity. The separation between any two neighboring magnets 6 is not critical and can be varied in the range of 10mm to 50mm. The dimensions of each magnet are the same. The cross sectional shape of the magnet 6 may be of square shape or of circular shape. If the cross sectional shape is of circular shape, the diameter may vary in the range of 5 mm to 40 mm. If the cross sectional shape is of square shape, comparable dimensions are taken. The height of the magnet 6 is not critical and can be lie in the range of 5 mm to 30 mm. Moreover, the strength of the magnetic fields 24 of the magnet 6 is also not critical. Usually the strength of the magnet 6 is selected to generate around 100 Gauss to 600 Gauss magnetic field on the lower surface of target member 2.

[0021]

When the magnets 6 are arranged over the target member 2 as explained before, magnetic field lines 24 emitted from any magnetic pole soon bend towards the nearest opposite polarized magnetic pole. Therefore, this magnet arrangement generates a cluster of point-cusp magnetic fields. Since the magnets 6 are arranged close to each other, magnetic field lines 24 bend within a short distance from the magnets 6. Therefore, this magnet arrangement yields strong magnetic field 24 at the vicinity of the inside region of target member 2 and decays very fast towards the lower electrode 3. Accordingly, by keeping an appropriate distance between the target member 2 and the lower electrode 3, a magnetic field-free environment can be obtained at the surface of the lower electrode 3.

[0022]

One pole of each magnet 6 is attached to the sheet 7, which is pr

eferably made of a metal. So the other pole of each magnet 6 faces the interior of the plasma-processing reactor 50. The sheet 7 in which the magnets 6 are attached is fixed within the cavity 13 between the upper electrode 1 and the target member 2 with the support of bearings 8. The sheet 7 can be rotated around the central axis of the upper electrode 1. Further, the magnets 6 are arranged to have a small separation, preferably about 1 mm, between the lower surface of the magnets 6 and the upper surface of the target member 2. In order to rotate the sheet 7 with the plurality of magnets 6, the upper surface of sheet 7 is connected to a motor 9 via suitable gear systems 10a and 10b. The gear systems 10a and 10b on the upper surface of sheet 7 are connected by a rod 11 made of an insulating material. This is important in order to eliminate the transmission of rf current to the motor 9 and the magnets 6. The rod 11 made of the insulating material passes through a small hole 12 made on the upper electrode 1. The diameter of the small hole 12 made on the upper electrode 1 is made as small as possible in order to prevent the conduction of rf current to the cavity between the upper electrode 1 and the target member 2. The magnet arrangement including the sheet 7, is rotated with a pre-decided frequency, usually around 5 to 10 Hz. The motor 9 is preferably placed outside the side wall 21 of the reactor 50 and operated by a DC or AC current. Even though the magnet arrangement is rotated as explained before, one can use a different technique to rotates the magnet arrangement, for example, a kind of magnetic coupling can be used. which eliminates the use of small hole 12.

[0023]

The composite structure of upper electrode 1, target member 2 and magnet arrangement is electrically isolated from the rest of the reactor 50 by placing on the dielectric rings 14a and 14b). The upper electrode 1 is connected to an rf power supply 16 via a matching circuit 15. T

he frequency of the rf power supply 16 is not critical and can be lie in the range of 10 MHz to 300 MHz.

[0024]

The lower electrode 3 is connected to an rf power source 18 via a matching circuit 19. The lower electrode 3 is given an rf electrical power from the rf power source 18. The frequency of the rf power source 18 is not critical and can be vary in the range of 0.1 MHz to 300 MHz. The rf power source 18 may be omitted. If the lower electrode 3 is not given the rf electric power, the electrical status of the lower electrode 3 may be of floating state or grounded state. The exact electrical status of the lower electrode 3 is determined by the respective wafer processing technique.

[0025]

There is a gas introducing system to the plasma-processing reactor 50 as shown in Fig. 1. A circular tube 20 with the plurality of gas inlets 4 is fixed to the inside of side walls 21. However, one may adopt a different technique to introduce process gas into the reactor 50.

[0026]

When the rf electrical power is applied to the upper electrode 1 from the rf power source 16, the rf current flows to the lower surface of target member 2 and generates a plasma by capacitively-coupled mechanism. Owing to the magnetic field 24 at the vicinity of the target member 2, the electrons in the plasma undergo cyclotron rotation and confine close to the target member 2. This results in an increase of plasma density. Since the magnets 6 are arranged to generate the plurality of curved magnetic fields 24 throughout the lower surface of the target member 2, high-density plasmas are generated within each set of curved magnetic filed lines 24. Depending on the number of magnets 6 arranged, the number of localized high-density plasma sites varies. By arranging large n

umber of magnets 6 close to each other, the number of high-density plasma generation sites can be increased. Therefore, the average plasma density below the target member 2 can be increased significantly compared to those of conventional plasma sources explained in prior art section.

[0027]

With the generation of plasma, the target member 2 gets negatively biased, because the surface area of the target member 2 is smaller than the grounded surface area where plasma is in contact with. Due to the negative self-bias voltage, ions in the plasma accelerate towards the target member 2, gain energy, and bombard on the target 2. This sputters the target member 2 to the plasma. A fraction of the sputtered atoms from the target member 2 passes through the plasma and deposits on the surface of the wafer 17. Another fraction of sputtered atoms re-deposit on the target member 2 due to the scattering in the gas phase. The remaining sputtered atoms deposit on the cylindrical side wall 21 and other surfaces, which are exposed to the plasma.

[0028]

Once the plasma is generated below the target member 2, electrons and ions at the vicinity of target member 2 get moved by E x B, where E and B are the DC electric field and magnetic field on the target surface respectively. This E x B drift of the plasma, however, is localized to smaller regions defined by the separation of magnets 6. Because, the magnets 6 are arranged to cancel out E x B drifts of the neighboring magnets. Therefore, this magnet arrangement yields almost radially uniform plasma a few centimeters below the target member 2 by the diffusion process. Further, due to the rotation of magnets 6, there are no re-deposition sites on the target member 2. This also causes an almost uniform erosion of the target member 2, which results in an increase of target utilization efficiency.

[0029]

As explained before, there is no magnetic field at the surface of lower electrode 3. Therefore, the rf electrical power from the rf power source 18 can be applied to the lower electrode 3 without distorting the plasma uniformity on the wafer surface. If there is a magnetic field on the wafer surface, plasma drifts to one side of the reactor 50 due to E x B drift, where E and B are respectively the strength of DC electric field and magnetic field on the wafer surface. By applying a suitable rf electrical power to the lower electrode 3, its self-bias voltage can be changed and thereby the energy of ions bombarding on the wafer surface can be changed.

[0030]

The plasma processing system of the first working example can yields a higher density plasma below the target member 2 compared to those of the conventional plasma sources. It can facilitate sputter deposition of metal films on the wafer with the uniform film deposition rate and the uniform erosion rate of the target member. Further, it can facilitate independent control of plasma density (or the ion flux) and ion energy bombarding on the wafer surface by controlling the rf electrical power applied to the upper electrode 1 and lower electrode 2, respectively.

[0031]

Next, the second working example of the present invention is explained in accordance with Fig. 3. This working example is an extension of the first working example. The upper electrode 1 in the second working example is supplied a DC bias voltage from a DC power supply 25 in addition to the rf electrical power from the rf power source 16. This DC power is supplied via a rf cut-off filter 26 that protects the DC power supply 25 from the rf current from the rf power source 16. Except this added structure, all the other configuration is the same as explained in t

he first working example. The other components shown in Fig. 3 substantially identical to those explained in the first working example are respectively designated by the same reference numerals.

[0032]

In the second working example, the application of the negative DC voltage larger than the self-bias voltage generated by the plasma results in an increase of sputtering rate of the target member 2. This results in an increase of film deposition rate on the surface of the wafer 17.

[0033]

The third working example is explained with reference to Fig. 4. The third working example is also an extention of the first working example. The upper electrode 1 in this working example is supplied another rf current from a secondary rf power source 27 via a matching circuit 28. With the application of the secondary rf current to the upper electrode 1, two rf filters 29 and 30 are added to the electrical circuit. The rf filter 29 cuts off rf current coming from the rf power source 16 and the rf filter 30 cuts off the rf current coming form the rf power source 27. Except this modification, all the other components are the same as those explained in the first working example.

[0034]

The frequency of the secondary rf power source 27 is lower than the primary rf power source 16, and preferably lies in the range of 0.1 MHz to 30 MHz. Application of the rf current with a lower rf frequency from the secondary rf power source 27 results in an increase of the self-bias voltage on the target member 2. This causes a higher sputtering rate of the target member 2 and thereby a higher film deposition rate on the wafer surface.

[0035]

The fourth working example is explained in accordance with Fig. 5. This working example is also an extension of the above working examples. That is, the hardware configuration of the fourth working example is the same as that of each working example. except for the magnet arrangement. Since only the magnet arrangement has been changed, only the magnet arrangement is shown in Fig. 5. Fig. 5 shows a side view of the plurality of magnets and the sheet 7.

[0036]

Except the height of each magnet 6, other dimensions of magnets, strength of magnets and separation between magnets are the same as those explained in the first working example. The height of magnets 6 varies in radial direction. For example, the height of magnets 6 becomes shorter towards the center of the sheet 7 or the target member 2 as shown in Fig. 5. One can change the height of magnets 6 on the other way. For example,
the height of magnets may become shorter towards the outer edge of the sheet 7. The criteria for the change of magnets' height is as follows.

[0037]

As explained in the first working example, when there is the magnetic field 24, the plasma density increases and plasma gets confined within the region of the magnetic field 24. The plasma density increment and the confinement-strength change depending on the strength of magnetic field. Therefore, by changing the height of magnets. the strength of magnetic field below the target member 2 can be changed and thereby the plasma density and plasma confinement can be changed. That is, the height of magnets can be treated as a controlling parameter of plasma density at the vicinity of target member 2. Depending on the type of wafer processing, applied rf power and pressure employed, it is important to change the radial profile of plasma density at the vicinity of target member

2 in order to get a uniform film deposition on the wafer surface. In these situations, the height of magnets is changed appropriately as described above to get a uniform film on the wafer.

[0038]

Similarly, one can change the strength of magnetic field 24 below the target member 2 by selecting magnets with different strengths of magnetic fields and by arranging them radially symmetric pattern.

[0039]

[Effect of the Invention]

The plasma processing system of the present invention can yields a higher density plasma below the target member by making the cluster of point-cusp magnetic field using the plurality of magnets having the predetermined arrangement. The plasma processing system of the present invention can facilitate sputter deposition of metal films on the wafer with the uniform film deposition rate and the uniform erosion rate of the target member. It can facilitate independent control of plasma density (or the ion flux) and ion energy bombarding on the wafer surface by controlling the rf electrical power applied to the upper electrode and lower electrode respectively. The present invention can provides a magnetically enhanced capacitively-coupled plasma processing system for sputter deposition applications with higher ion concentration, higher ion flux uniformity on the substrate surface and without the re-deposition of sputtered materials back on the target member.

4. Brief Explanation of Drawings

[Fig. 1]

This figure is a cross sectional view of the first working example showing the capacitively-coupled electrodes, a target member and a magnet arrangement.

[Fig. 2]

This figure shows magnet arrangement used in the first working example.

[Fig. 3]

This figure is a cross sectional view of the second working example.

[Fig. 4]

This figure is a cross sectional view of the third working example.

[Fig. 5]

This figure is a side view of the sheet and the magnets in the third working example..

[Fig. 6]

This figure is a schematic view showing the first conventional plasma source used for plasma processing.

[Fig. 7]

This figure is a top view of the upper electrode shown in Fig. 6.

[Fig. 8]

This figure is a schematic view showing the second conventional plasma source used for plasma processing.

[Fig. 9]

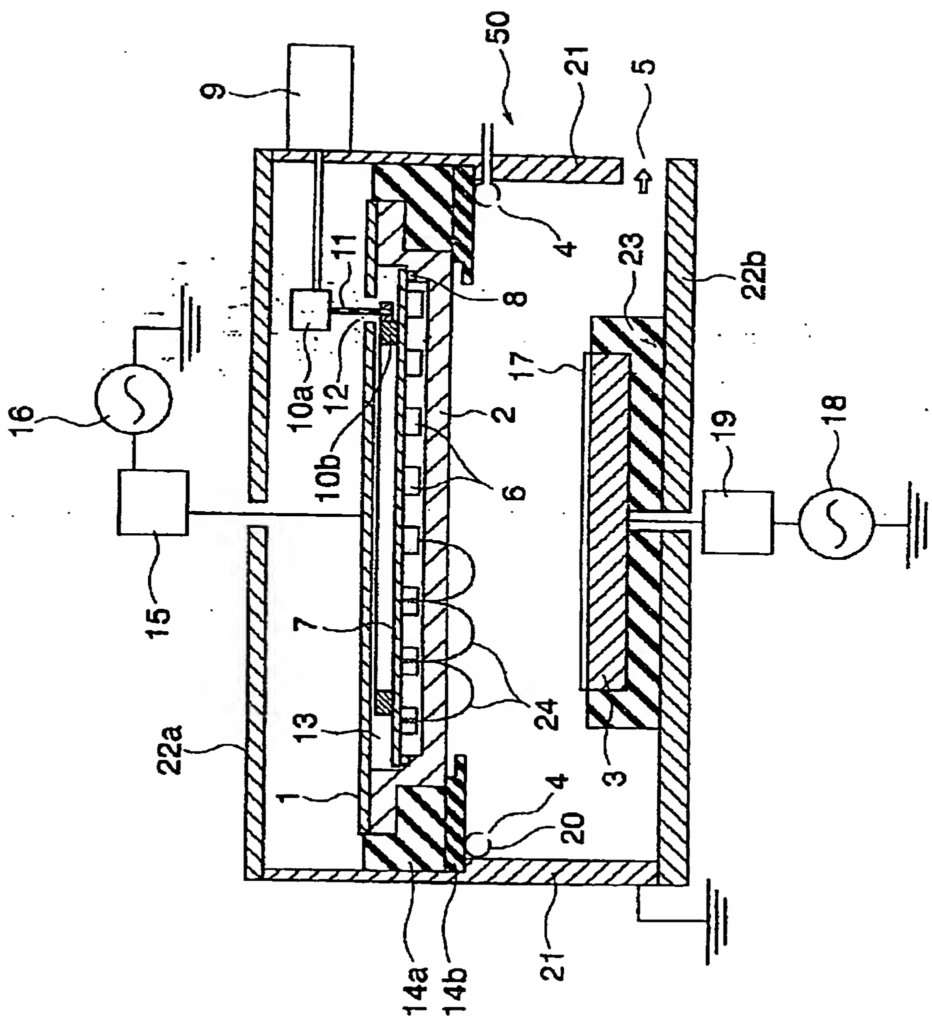
This figure is a top view of the upper electrode shown in Fig. 8.

[Explanation of Reference Signs in Drawings]

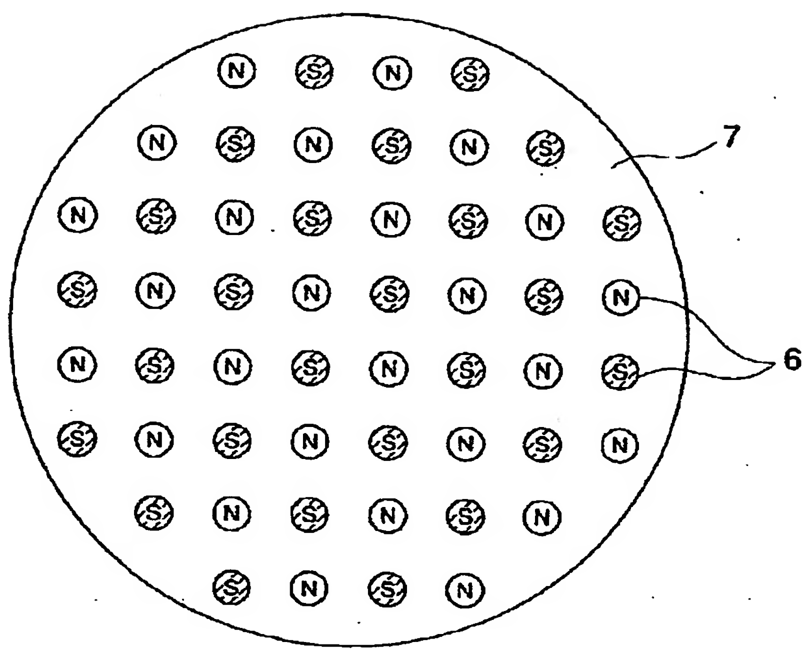
1	Upper electrode
2	Target plate
3	Lower electrode
6	Magnet
17	Wafer
21	Cylindrical side wall

21b	Bottom plate
23	Wafer holder
50	Reactor

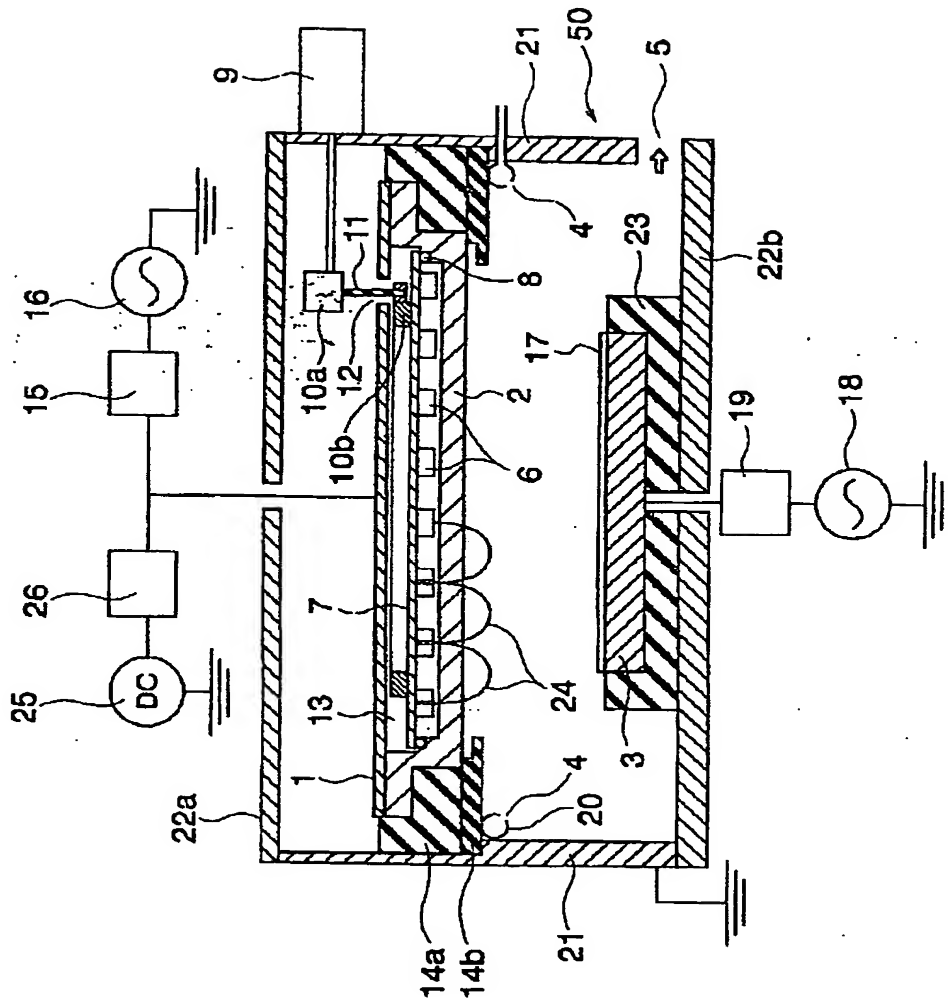
【Fig.1】



【Fig.2】



【Fig.3】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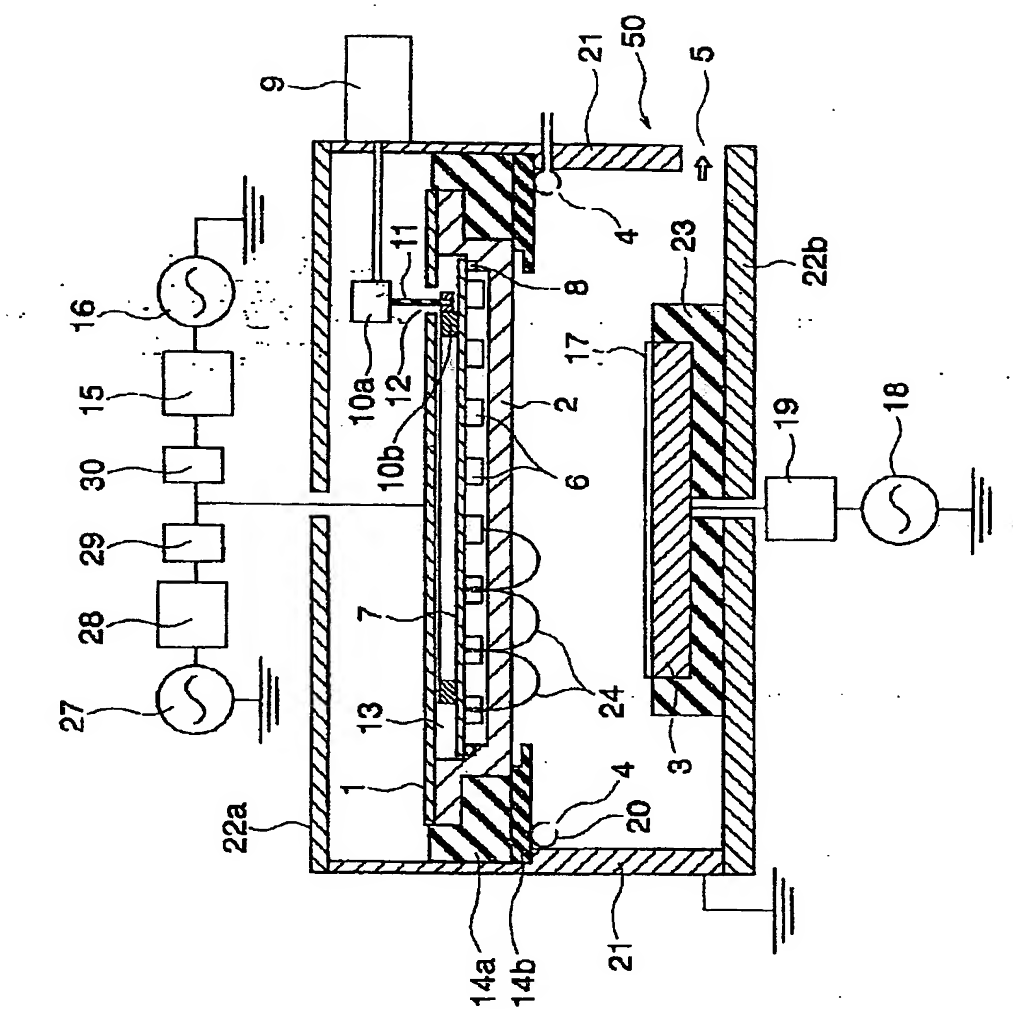
22a
14a
14b
21

【Fig.4】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22b
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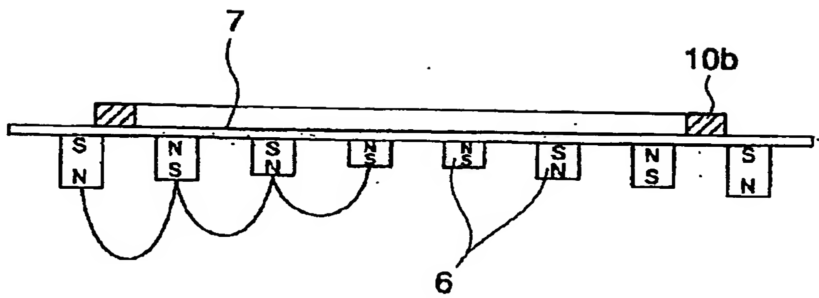
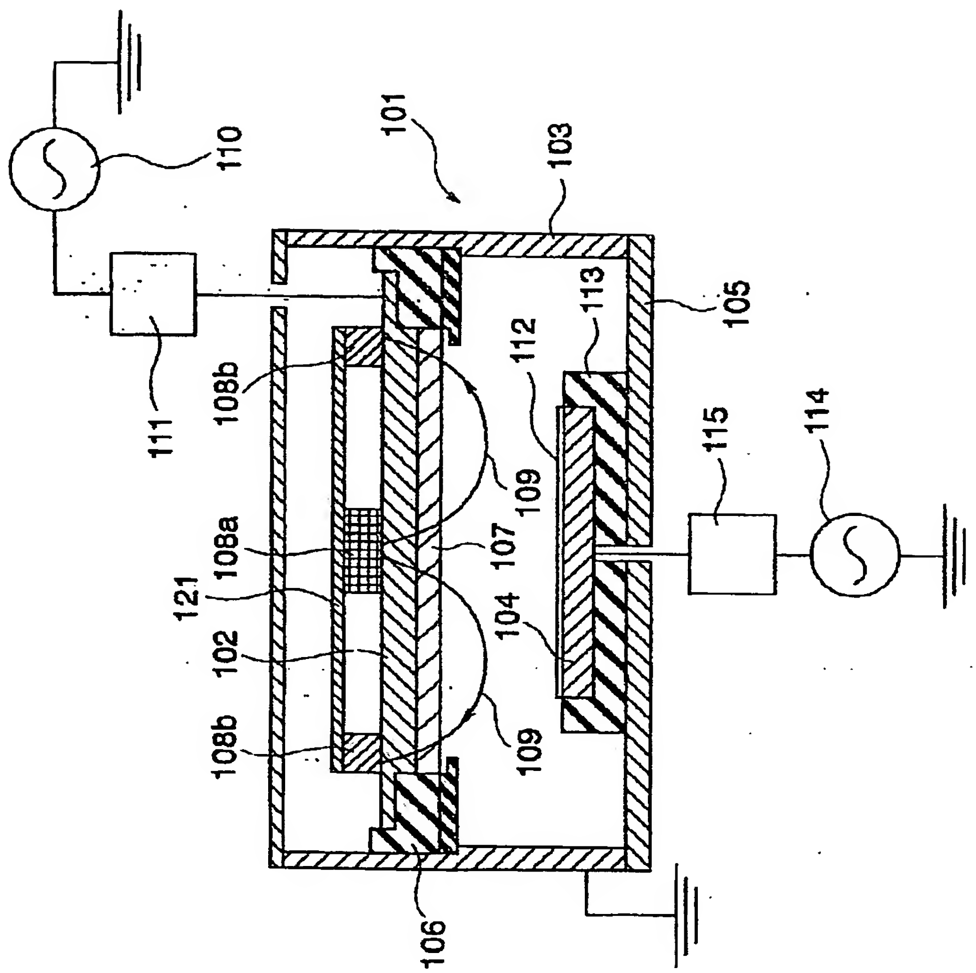
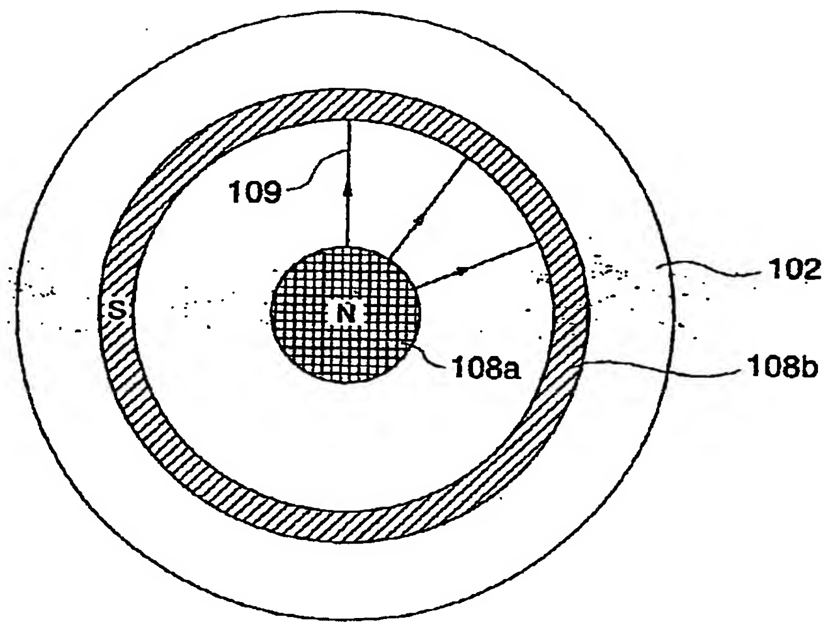
【Fig.5】



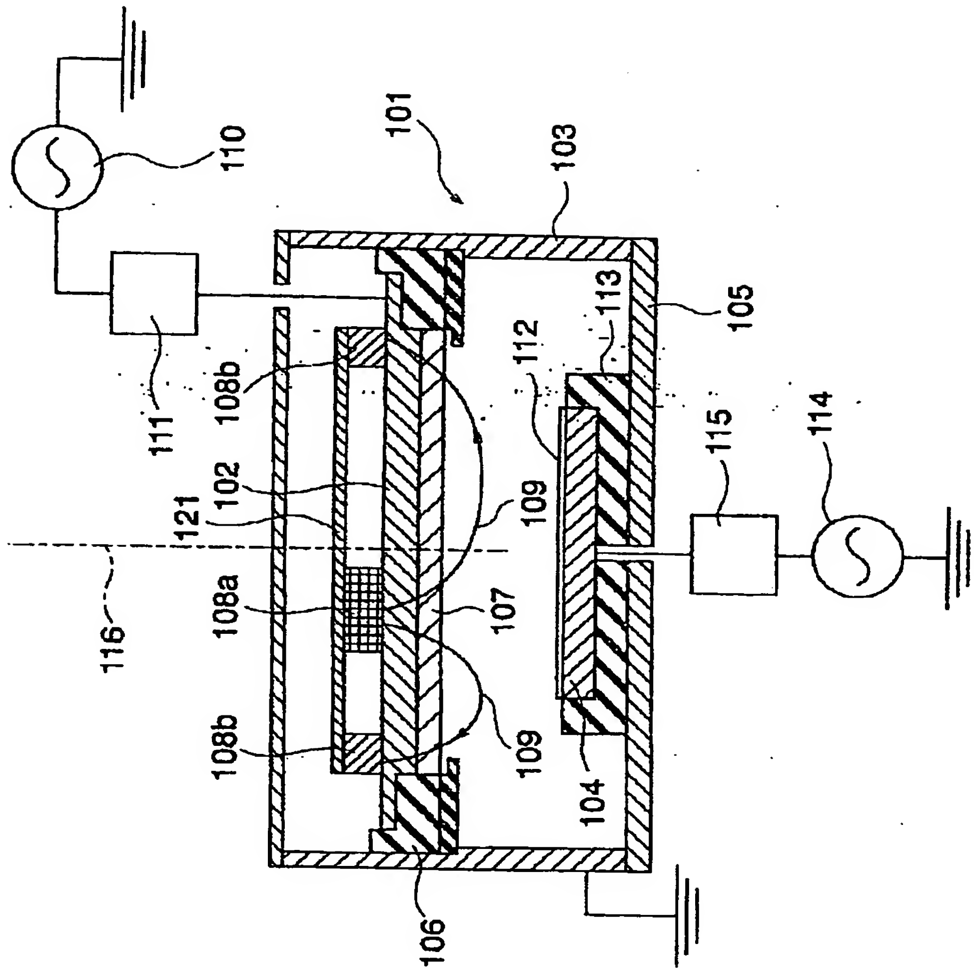
【Fig.6】


101
102
103
104
105
106
107
108a
108b
108b
109
109
110
111
112
113
114
115
121

【Fig.7】



【Fig.8】


101
103
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108a
108b
108b
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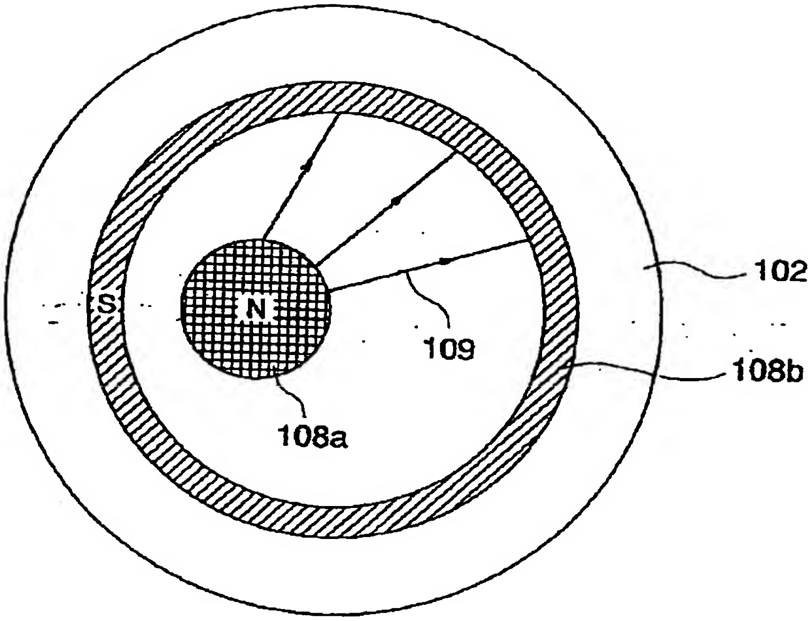
121
102

【Fig.9】



1. Abstract

A plasma processing system for sputter deposition applications provided with an upper electrode 1 with a capacitively coupled mechanism; a target member 2 of non-magnetic material attached to the upper electrode; a plurality of magnets 6 arranged over the upper surface of the target member, which have a equal distance between two of them and alternate polarity; a lower electrode 3 placed parallel to the upper electrode; a wafer 17 loaded on the lower electrode; an rf power source 16 operates at a frequency in a range of 10 MHz to 300 MHz and is connected to the upper electrode via a matching circuit 15.

2. Represent Drawing Fig.1